Temperature Management in Children

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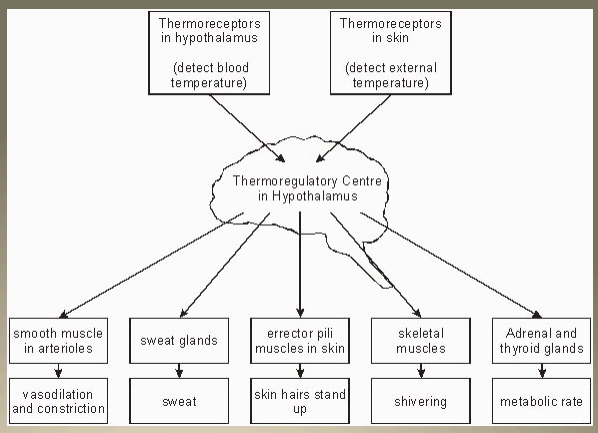
Normal Temperature Regulation

- Delicate balance
- Narrow range
  36.5-37.5C
- Optimum Enzyme function

HOW??



- Afferent input –Aδ & C fibres
- Central Control - Hypothalamus
- Efferent Responses – Behavioural & Autonomic

Behavioural Responses exceed combined autonomic abilities

Responses to cold stress

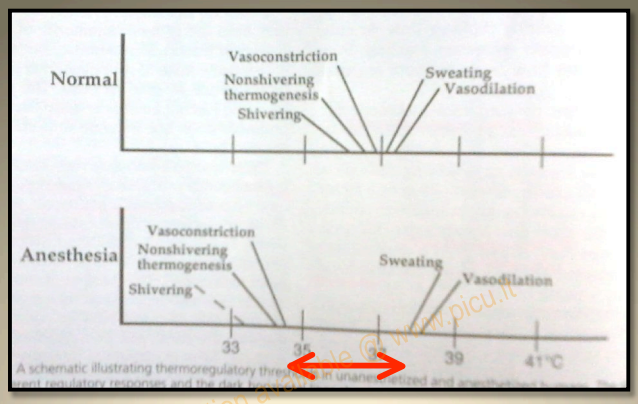
- **Vasoconstriction**
  decreases heat loss 25-50%.
- **Non-shivering thermogenesis**
  Inc metabolic activity without muscular activity
  Brown fat, 1st 2 yrs of life
  Prematures can double the metabolic rate
- **Shivering**
  Older children

Responses to heat stress

- **Sweating**
  Post ganglionic cholinergic NF
  Effective defense --hyperthermia.
  Atropine (0.5mg) impairs increasing threshold & reducing gain.
- **Active pre-capillary vasodilation**
  Increases Cutaneous BF enormously.
  Unique human response
  1mm area of skin blood flow equals CO

Anaesthesia .....

Change in threshold for all but gain & maximum response remain same



What else...

- Nearly constant core temperature
- Peripheral tissue temperature falls
- 1°-5°C core-peripheral temperature gradient
- Legs Peripheral thermal buffer (anatomic mass)

  allow individual to lose heat in a cold environment or absorbs heat in a warm environment without altering the core body temperature.
- When core temp falls <36°C it is termed as Perioperative Hypothermia

Pattern of Intraoperative Hypothermia

Initial phase
–Redistribution Hypothermia

- Peripheral vasodilation & opening of AV shunts
- Redistribution Core body heat- periphery
- Core Temp Falls 1.0-1.5°C
  1st hour

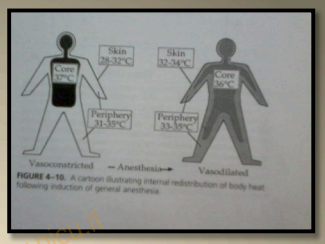


FIGURE 4–10. A cartoon illustrating internal redistribution of body heat following induction of general anesthesia.

Hypothermia…

- **2nd phase-**
  Core Temperature falls as heat loss > heat production
  Around 90% by radiation and convection
  5% by evaporation and 5% by conduction
- **Plateau phase**
  After 3-5 hrs when heat loss =heat production
  Normal core-to-peripheral temperature gradient Restored
  But at a hypothermic level (33°C core body temperature)

How children are different?

- Globular bodies-
  - -Larger fractions of mass in the torso
  - -Head larger fraction of surface area
  - -Redistribution contributes less to intraop hypothermia
- Cutaneous heat loss α surface area
  Metabolic heat production α mass
- Children lose more heat via skin as compared to heat production
- But Thermoregulatory vasoconstriction is well maintained once triggered it helps prevent further hypothermia.

Regional Anaesthesia

Interferes with

- Afferent transmission of thermal signal are altered hence blocked area is sensed as warm area
- Inhibition of vasoconstriction-- hypothermia 1st hour
- Vasodilation produced -minimally increases cutaneous heat loss
- Metabolic heat production =/+

CONSEQUENCES OF HYPOTHERMIA

Benefits

- Marked protection against tissue ischemia and hypoxia
- Temperatures of 25-30°C have been used for cerebral protection during CP Bypass
- Just 2-3°C core hypothermia provides more protection against ischemia than any other pharmacological treatment, e.g., neurosurgery.

CONSEQUENCES OF HYPOTHERMIA

Risks-

- Patient discomfort
- Increased bleeding(decreased platelet function)
- Increased duration of action of drugs like atracurium and vecuronium
- Mild hypothermia triples SSI (impaired immune function and reduced cutaneous blood flow) Level I Gr B
- Shivering increases

  - Oxygen consumption(200%)
  - Pain, intra-ocular and intra-cranial pressures.

PREVENTION AND TREATMENT OF HYPOTHERMIA

- Before Premedication
- Shifting to OT

Concept of pre-warming

- 20min, immediately before induction
- Reduces the core-to-periphery temperature gradient & redistribution hypothermia
- Level I Gr B recommendation

Forbes et al, "Evidence Based Guidelines for Prevention of Perioperative Hypothermia" *Journal of American College of Surgeons,* vol 209,no 4 Oct 2009

Cutaneous warming-

- Ambient temperature critical factor for heat loss
- Temperature >23°C are required to maintain normothermia.

Passive Warming

- cotton blankets
- surgical drapes
- plastic sheets
- Single layer reduces heat loss by 30%, while three layers reduce by 50%.
- The amount of skin covered is more important than the site and type of insulator

Kurz A, "Prevention & treatment of perioperative hypothermia", *Current Anaesthesia & Critical Care vol12, 2001,p96-102*

Active warming

- Circulating water / Forced air
- Circulating water mattresses
  - -ineffective when placed underneath
  - -more effective when kept over the patient
- Skin warming increases mean body temperature but is far more effective in increasing core temperature when patients are vasodilated.
- Forced Air better than circulating Water (Level I Gr B)

Scot EM, " A Systematic Review of Intraoperative Warming to prevent PO Complications", AORN,May2006,vol83,n05

Warming IV fluids

- Large volumes
- In major surgery the combination of forced air and fluid warming was more effective in maintaining body temperature than forced air alone or warming alone.

Level I Gr B

Supportive Measures

- Warm Irrigation fluids
- Airway Heating and humidification
  - More effective in infants and children than adults
  - Cannot prevent core hypothermia
  - Maintain ciliary function in trachea

HME

Safety of Warming Devices

- One report – 2nd & 3rd Degree burns in 3yr old child after CP bypass , *Truell & Colleagues*
- Potential risk of SSI with Forced air devices – the microbes found were not the ones causing SSI

  Avidan & Colleagues

Monitoring sites

- Pulmonary artery
- Distal esophagus – Level II Gr B
- Naso-pharynx
- Rectal
- Oral –Level II Gr B
- Axillary
- Bladder

Continuous /15min interval

Evidence against Infra-red tympanic membrane thermometry (Grade D recommendation)

Forbes et al, "Evidence Based Guidelines for Prevention of Perioperative Hypothermia" *Journal of American College of Surgeons,* vol 209,no 4 Oct 2009

How to maintain Normothermia

- Monitor temperature (15min/continuously)
- Maintain temperature
  -Shifting to OT
  -Peri-operatively
- Pre-warming
- Active Warming if Temp <36°C
- Passive Cutaneous warming
- Warm IV, Irrigation Fluids
- Limit skin exposure
- Keep Ambient temp >23°C

HYPERTHERMIA & FEVER

- A core body temperature exceeding normal values is hyperthermia.
- It does not imply a specific etiology or mechanism
- Fever is a regulated increase in core temperature mediated by endogenous pyrogens and actively maintained by thermoregulatory responses.

Malignant Hyperthermia

- MH is an acute hypermetabolic syndrome triggered by succinylcholine and volatile anaesthetics.
- Onset of MH - fulminant & rapid
- Symptoms - skeletal muscle rigidity, hypercarbia, fever
- Can progress within 30 minutes to a premorbid state in which the arterial pH is as low as 6.6 units
- Central thermoregulation is maintained during MH
- Temperature increases because continuous muscle contracture generates more heat than the body can dissipate to the environment.

Treatment

- Hyperventilation with 100% O_2
- IV Dantrolene 2.5 mg/kg initially, followed by 6 hourly doses till 24 hrs
- Sodium Bicarbonate 1-2 mEq /kg IV, if $PaCO_2$ is normal and pH is low
- Frequent ABG, Electrolytes, Serum CPK levels are required.
- In-vitro caffeine/ halothane contracture test reliably diagnoses the syndrome.